Assessment Regressivity and Property Taxation

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Abstract

Homestead exemptions typically produce a moderately progressive statutory incidence for the property tax in the US when progressivity is measured using the ratio of a household's tax to the sale price of a home. However, the tax is levied on the assessed value of a home rather than the sale. A stylized fact from the assessment literature is that assessment rates tend be lower for higher-priced home. In this paper, we first document the pattern of assessment regressivity. Next, we show that this pattern of regressivity is capable of reversing the statutory progressivity incidence of the property tax, particularly for low-priced homes. We then use HMDA data to show that this pattern of assessment regressivity also leads to regressivity when measured as the ratio of taxes to household income.

1. Introduction

Homestead exemptions are a common feature of the property tax in the United States. For example, Philadelphia exempts the first $40,000 of property values from the tax. Homestead exemptions imply a progressive tax structure when progressivity is measured as the relationship between tax payments and property values: owners of low-priced homes are expected to pay little or no tax while the influence of the exemption eventually becomes negligible for high-priced properties. Despite this common feature of the tax system, the property tax is often viewed as regressive, and this perception is one of the factors leading to the widespread unpopularity of the tax (Anderson, 2006; Cabral and Hoxby, 2015; Rosengrad, 2012; Youngman, 2016).

Administrative practices can significantly alter the apparent simplicity of what typically is a linear relationship between tax payments and property value. Property values must be estimated, and it is the assessed value that forms the base of the property tax. One of the stylized facts of the literature on property assessments is that assessment rates – the ratio of assessed value to the sale price of a property – tend to be higher for low-priced properties. The source of this form of regressivity is unclear, and it is not ubiquitous: results presented in McMillen and Weber (2010) and McMillen (2013) suggest that it is not due to a higher success of appeals for high-priced properties, and some studies have found the opposite result, particularly for jurisdictions with high concentrations of non-residential property (Smith, Sunderman, and Birch, 2003; Sirmans, Gatzlaff, and Macpherson, 2008). But what is clear is that regressive assessment practices have the potential to reduce or even reverse the statutory progressivity of the property tax system in the US, and the vagaries of the assessment system may be responsible for the widespread unpopularity of the tax.

Although there is a vast literature on the incidence of the property (some of which is surveyed in Oates and Fischel, 2016), it is largely theoretical and the effect of assessments on the incidence appears to be neglected entirely. This paper makes two contributions to the literature. First, we document the patter of assessment regressivity for four large urban counties, and show that it can reverse the statutory progressivity of the property tax. Second, we take advantage of recently proposed procedures for merging data on house sales with loan data to obtain data on household income. The resulting data set allows us to analyze the relationship between property taxes and income. The results suggest that average household taxes – the ratio of taxes to income – decline with income, particularly at high income levels. This form of regressivity is accentuated by regressive assessment practices in those jurisdictions where our results imply that assessment rates are higher for low-priced properties.

The rest of the paper proceeds as follows. First, we summarize the statistics that are commonly used to measure assessment regressivity and present the results for a set of large central city counties. Next, we use statutory tax schedules to compare the implied tax payments based on actual assessments to the taxes that would be paid if the homes were assessed at their sales prices. We then use these estimated tax payments to calculate the relationship between taxes and household income.

2. Traditional Assessment Measures

The International Association of Assessing Officers (IAAO) promulgates methods and procedures for evaluating assessment performance. The most commonly used statistics focus on the assessment ratio, i.e., the assessed value of a property divided by its sale price. It is common throughout the US for the statutory assessment rate to be a fraction of the market value. For example, the statutory assessment rate for residential properties is 35% in Ohio and 7.96% in Colorado. Some states have a classified system in which different categories of properties (e.g., commercial v. residential) are assessed at different rates, and some states have different statutory tax rates for different types of properties. The Lincoln Institute of Land Policy maintains an exceptional data base summarizing property tax practices across states at https://www.lincolninst.edu/research-data/data/state-state-property-tax-glance.

Means, medians, and value-weighted means are the most commonly used measures of the central tendency of assessment ratio distributions, with emphasis often placed on the median due to the frequency of apparent outliers, particularly at the high end. The value-weighted mean is calculated by weighting each ratio by its sale price. The common finding that the value-weighted mean is lower than the arithmetic mean implies that high-priced properties tend to be assessed at lower rates on average.

The IAAO also proposes two variations of the coefficient of dispersion (COD) to measure the variability of the assessment ratio distributions. The standard COD is simply the average percentage deviation of the assessment ratios from the median ratio. The value-weighted COD uses sales prices to place more weight on high-priced properties in the calculation. IAAO standards for "appraisal uniformity" call for COD's below 15 for residential properties.

The primary statistic advocated by the IAAO for measuring regressivity is the "price-related differential" (PRD), which is the ratio of the arithmetic mean to the value-weighted mean. The PRD will exceed one if high-price properties are assessed at higher rates than low-priced properties. IAAO standards call for vertical equity call for PRD's ranging from 0.98 to 1.03.

Academic researchers have tended to rely on regression-based methods to evaluate assessment regressivity. The extensive literature on the subject is reviewed by Sirmans, Gatzlaff, and Macpherson (2008) and Carter (2016). The earliest study appears to have been by Paglin and Fogarty (1972), who suggested testing whether the intercept is significantly different from zero in a regression of assessments (A) on sales prices (P). Cheng (1974) proposed testing whether the coefficient on lnP equals one in a regression of lnA on lnP and, with values under one implying regressivity. Clapp (1990) reversed the regression, using lnP as the dependent variable and lnA as the explanatory variable. Clapp also suggested using an instrumental variable in place of lnA. The IAAO has proposed other procedures that use the assessment ratio as the dependent variable (or the percentage deviation of A/P from its median) and some measure of market value as the explanatory variable.

All of these regression-based measures have serious deficiencies. In McMillen and Singh (2018), we consider the case where assessments are the predicted values from either a linear or log-linear regression of sales prices on a set of housing characteristics. We show that the estimated coefficient on P from a regression of A on P is by construction equal to the R^2 from the original regression of P on X when the true hedonic model is $P = X\beta + u$. The result is identical for a hedonic model with lnP as the dependent variable when the assessments are evaluated by regressing lnA on lnP. Similarly, the coefficient on $\ln P$ from a regression of the log assessment ratio, $\ln(A/P)$, on $ln\, P$ is equal to $R^2 - 1 \leq 0$. Thus, each of the approaches necessarily leads to a finding of regressivity. Although in practice assessments are typically evaluated using a sample for which at least a portion of the sales are not used to calculate the assessed values, the implication is clear: regression-based methods are biased toward a finding of regressivity.[1]

Given these deficiencies of regression-based procedures, we will rely primarily on the traditional PRD measure to evaluate the degree of regressivity. Since our ultimate objective is to show how using the actual sale price as the basis of the property tax would alter the relationship

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[1] The situation is no better for a recently proposed IAAO measure, the "price-related differential," because the explanatory variable also includes assessments, which again implies a correlation with the dependent variable. Similarly, the estimated coefficient on P from a linear regression of A/P on P is typically biased downward.

of taxes to income, and more generally to show the relationship between taxes and household income, it is not critical that we begin with an ideal measure of assessment regressivity. As a potential improvement, we also compare Gini coefficients for sales prices and assessments. The Gini coefficient is derived from the Lorenz curve, which in the case of sale price shows the cumulative share of value associated with prices ranging from the lowest to the highest priced properties. Complete equality of prices implies a 45 degree line for the Lorenz curve; more unequal distributions of sales prices produce greater curvature in the Lorenz curve. The Gini coefficient is the area between area between the Lorenz Curve and the 45 degree line divided by the full area under the 45 degree line. A Gini coefficient for sale price thus equals one if all prices are identical, while values closer to zero imply a more unequal distribution of prices

When the data are ordered from smallest to largest, the formula for the Gini coefficient for a variable x is $G = 2(\sum_{i=1}^{n} i x_i)/(n \sum_{i=1}^{n} x_i) - (n+1)/n$. To make a direct comparison of assessed values to sales prices, we order the data from smallest to largest sale price and maintain the same ordering for both prices and assessed values when calculating the Gini coefficients. The Gini coefficient for sale price is the standard one; the Gini coefficient for assessed values measures the difference between the 45 degree line and the curve showing the share of assessed value associated with the smallest through largest sale price. Letting G_a and G_p represent the Gini coefficients for assessed values and sales prices, the G_a will be less than G_p if assessment ratios are higher for low-priced properties than for high-priced properties, i.e., if assessments are regressive. We use a standard bootstrap resampling procedure to determine whether the difference in Gini coefficients is statistically significantly different from zero.

3. Data

The primary data source for the study is CoreLogic, which provided data on sales, assessed values, and property tax payments. The four counties used in this paper are listed in Table 1. Counties are an appropriate unit of analysis for a study of assessments because the authority for assessing properties lies with counties in most states, and property tax schedules sometimes vary across counties within a state. Although there are locations in which exemptions can vary by municipality, working with counties is still worthwhile because we construct tax estimates using the standard tax schedule for the central city county. The county is equivalent to the city for Baltimore, Denver, and Philadelphia. Cuyahoga County both the central city and parts of suburban Cleveland.

We impose a set of restrictions on the data to ensure a sample of arm's length, residential sales. We drop foreclosures, sales between family members, multiple-property transactions, and sales with unusual deeds. We use a nonparametric trimming procedure advocated by the IAAO to trim any remaining outliers. For a variable *x*, the trimming procedure drops observations that are outside the range $[p_{.25} - 3(p_{.75} - p_{.25}), p_{.75} + 3(p_{.75} - p_{.25})]$, where $p_{.25}$ and $p_{.75}$ represent the 25th and 75th percentile of the values of *x*. We apply the trimming procedure to the log of sale price, the log of the assessed value, the assessment ratio, and the tax to sale price ratio.

We use sales from 2014-2016 to evaluate assessments for 2016 for Baltimore, Cleveland, and Denver. Similarly, we use sales from 2016 and 2017 to evaluate assessments for Philadelphia, which date from 2017 (sales data for 2018 are not yet available). To match the timing of the sales with the assessment dates, we construct a repeat sales price index using the county's sample of residential sales for 1996 – 2017 We then adjust the sales prices to the first quarter of the assessment year. All subsequent calculations are based on the adjusted sales prices, including the nonparametric trimming procedure.

Tax schedules are drawn from the Lincoln Institute of Land Policy's online data base. The typical tax schedule is conceptually simple: $T = \max\left\{\tau\left(\frac{A}{P}P - E\right), 0\right\}\tau$, where τ is the tax rate, *A*/*P* is the assessment rate, *P* is the market value of the property, and *E* is the exemption. Table 1 shows the statutory assessment rate and the base homestead exemption for the central city counties included in our sample. Baltimore, and Philadelphia are supposed to assess properties at full market value. The statutory assessment rate is 0.35 in Cleveland (Cuyahoga County) and 0.0796 in Denver. [2] In practice, we observe the sale price, P, and the assessed value, $A = \frac{A}{P}P$. The question is whether actual assessments ratios, *A*/*P*, are close to the statutory rates.

Exemptions can vary significantly across households. In addition to the standard homestead exemption, exemptions are sometimes available to senior citizens, military veterans, and other favored groups. Since our data set does not include an indicator of the household's exemption status, we assume that all households take the standard homestead exemption. We then compare the taxes implied by the tax schedule when properties are assessed at their sales prices to the taxes implied by the observed assessed values. Although this approach does not produce a strictly accurate accounting of tax payments, it has the advantage of isolating the effects of assessment practices on statutory rates: if a household takes the standard exemption, what would it owe in taxes if the property were assessed at the sale price instead of the actual assessed value?

[2] The assessment ratio (assessed value divided but market value) is .072 for Denver for the 2017 and 2018 tax years but was .0796 before that.

The approach also has the advantage of standardizing the tax schedule across counties, which again helps to isolate the influence of assessment practices.

The tax calculation requires information on the tax rate charged in each jurisdiction. Tax rates are set endogenously in most states: the jurisdiction is authorized to raise a given amount of revenue from the property tax and then a tax rate is implied given the assessments within the jurisdiction. An exception in our current data set is Ohio, where jurisdictions vote on the actual tax rate. In some states, tax rates can vary by property class, and there can be significant variation within an urban area in the tax rates for apparently similar properties. Since information on tax rates is extremely difficult to compile at the property level, we calculate tax rates (τ) for each county by finding the rate that would produce the actual amount of revenue raised for our sample of observations. Thus, if T_i is the actual tax payment by property *i* and A_i is its assessed value, we set $\tau = \frac{\sum_i \max((A_i - E),0)}{\sum_i T_i}$. When evaluating the taxes that would be paid by households if their property were assessed at its actual sale price, we re-calculate the tax rate by substituting P for A in the formula in order to ensure that revenue is held constant. Calculating tax rates in this way assures that it is the difference between assessed values and sales prices that are leading to any differences in the applied tax.

The final piece of data need for our analysis is a measure of household income. We use a procedure pioneered by Bayer, et al. (2016) to merge HMDA data on loans with our sample of home sales using a fuzzy matching procedure based on mortgage amount, mortgage year, census tract, and lender's name. Although this procedure provides a measure of current rather than permanent income, it provides the information needed to construct a measure of the burden of the relationship between property taxes and income for a large number of individual households.

4. Assessment Statistics

Table 1 presents a set of summary statistics for the 4 counties. The median is well below the statutory assessment rate in all four counties. The median conceals significant heterogeneity: in each case: the COD implies that the average absolute deviation of the assessment ratios from their median value for the county is greater than 15%, which is the IAAO's guideline for residential assessments. The value-weighted COD's are lower than the unweighted values in Baltimore, Cleveland, and Philadelphia, which suggests that there is greater variability in assessments for relatively low-priced properties. Most importantly for our purposes, the PRD's exceed one, although in Denver the value of 1.015 is within the IAAO's recommend standard of 1.03. The values for the PRD imply that assessments tend to be regressive, particularly in Baltimore.

Figure 1 presents plots of assessment ratios and the log of sale price for the four counties. The graphs also show the estimated regression lines (the solid red lines) and the statutory assessment rates (the horizontal blue lines). PRD values of 1.316 for Baltimore, 1.160 for Cleveland, and 1.158 for Philadelphia imply regressivity. This pattern is evident in Figure 1 in the clear nonlinear relationship between sales prices and assessment ratios. Properties with low sales prices are much more likely to have very high assessment ratios than low-priced properties. A more moderate version of the same regressive pattern is evident in Denver despite its low PRD of 1.015.

Figure 2 presents an alternative view of the relationship between sale price and the assessment ratio. Following McMillen (2013), we use conditional kernel density functions to show how increases in sale price are associated with changes in the distribution of assessment ratios. Using x to represent the log of sale price and y to denote the assessment ratio, the conditional assessment ratio density is $f(y|x) = f(x, y)/f(x)$. At a target log sale price, the kernel density estimates are $f(x) = \frac{1}{bs_x n}\sum_{i=1}^{n} K\left(\frac{x_i - x}{bs_x}\right)$ and $f(x,y) = \frac{1}{bs_x bs_y n}\sum_{i=1}^{n} K\left(\frac{x_i - x}{bs_x}\right) K\left(\frac{y_i - y}{bs_y}\right)$. We use the 10th, 50th, and 90th percentile of the log sales prices as the target for each city, and use a Gaussian kernel weight function with a constant bandwidth for both variables.[3]

The estimated conditional density functions are extremely wide for Baltimore at the 10th percentile of the sale price distribution. At higher prices, the assessment ratio distributions hone in on values closer to but below the statutory rate, and the incidence of very high ratios declines dramatically. Similar patterns are evident in Cleveland and Philadelphia. Only in Denver is there not a clear tendency toward lower assessment ratios and lower variability at higher sales prices. .

Gini coefficients provide another way to view the regressivity of assessment practices. Figure 3 shows the Lorenz curves for sales prices and assessments for four of the central city counties. For both prices and assessments, the x-axis represents the order of sales prices. All of the curves lie well below the 45-degree line because sales prices and assessments are both far from following equal distributions. In Baltimore, the Lorenz curve for assessed values lies well above the Lorenz curves for assessments, which implies that the distribution of assessments is closer to being equal than the distribution of sales prices. This pattern occurs when assessment rates are higher for low-priced properties than for high-priced properties, i.e., when assessment are regressive. The Lorenz curves suggest that the degree of regressivity is more moderate in Cleveland and Philadelphia, and may even be progressive in Denver.

[3] The bandwidth is a variant of Silverman's rule of thumb, $b = .9n^{-.2}min(s, (q_{.75} - q_{.25})/1.34)$, where n is the sample size, s is the standard deviation of the variable, and $q_{.25}$ and $q_{.75}$ are the 25th and 75th percentiles.

The Gini coefficients for our sample of central city counties are presented in Table 2. Standard errors are calculated using a standard bootstrap resampling procedure with 1000 replications. The values of the Gini coefficients can be compared directly across cities.

The difference in the Gini coefficients provides a measure of the degree of assessment regressivity. The difference in the coefficients is significantly negative, i.e., the distribution of assessments is more uniform than the distribution of prices, in all four cities, but the value is close to zero in Denver despite being statistically significant.

5. Taxes

The CoreLogic data set includes property taxes. Using this information, we measure the effective tax rate as $ETR = T/P$. We also estimate taxes using the statutory tax schedule, under the assumption that all property owners take the standard homestead exemption and are subject to a common tax rate, which we calculate as the one that raises the same revenue as observed within the sample of actual tax payments. We then calculate the taxes that would be paid if the market value of the assessments were set at the actual sale price, and we recalculate the tax rate to again ensure that the same revenue is always raised from the set of properties in the sample. Comparing the two sets of estimated taxes ensures that we are isolating the effect of assessment practices on tax payments.

Figure 4 shows the estimated effective tax rates for four central city counties. The scatter of actual sale price – ETR combinations shows that effective tax rates are highly regressive in Baltimore, Cleveland, and Philadelphia when regressivity is measure as a decline in the ETR when sales prices increase. As expected, the scatter of ETR values shown in Figure 4 is quite similar to the scatter of assessment ratios in Figure 1. The solid red lines in Figure 4 show the predicted prices from a locally weighted regression (LWR) of ETR on the log sales prices.[4] In all four cities, the conditional expectation of the effective tax rate is higher for low-priced properties. In contrast, the statutory ETR does not vary with sale price in Baltimore, Cleveland, and Denver, and it increases with sale price in Philadelphia due to the homestead exemption. In Philadelphia, the frequency of high assessment rates for low-priced properties is sufficient to reverse the statutory progressivity of the tax code. The other cities in our sample do not have a homestead exemption, so tax payments should be proportional to sales prices. But again, the large number of high assessment rates for low-priced homes leads to a regressive tax incidence, although the pattern of regressivity is only evident in a region of very low sales prices in Denver.

Table 3 presents estimated Gini coefficients for the actual taxes, estimated taxes, and the difference between the taxes calculated using assessment and sales prices. Since the estimated taxes are linear functions of assessments and prices, the Gini coefficients are very close to those presented in Table 2. The main difference between Tables 2 and 3 is that the signs of the percentage differences presented in the last column of the tables are different because the sale price is the base in Table 2 and the tax based on assessments is the base in Table 3. The implication of Table 3 is that taxing sales prices rather than assessments would lead to less regressive tax systems in Baltimore, Cleveland, and Philadelphia.

[4] The LWR predictions are calculated using weighted least squares regressions of ETR on $\ln P$ at a set of target points, followed by interpolation to the other values of $\ln P$. We use a tri-cube kernel with a 10% window.

6. Income

Although the ETR – the ratio of tax to sale price – suggests that the property tax is regressive, it does not directly imply a relationship between taxes and income. If the income elasticity of demand for housing were equal to one, a finding that the ETR declines with sale price would imply that tax payments divided by income, *T/I*, also decline with income. Albouy, Erlich, and Liu (2016) survey the literature and conclude that the best estimate of the income elasticity of housing demand is approximately 0.80, although there is a wide variety of estimates in the empirical literature. Since most of the estimates are under one, it is reasonable to conclude that housing expenditures will rise less than proportionately with income. Thus, both the income elasticity and the regressivity of assessment practices suggest that *T/P* will decline with *P* in jurisdictions without a homestead exemption. A homestead exemption can potentially reverse this regressivity for low-priced properties.

Traditionally, data sets on home sales included sales prices and characteristics of the homes, but little or no information on characteristics of the seller. Bayer, et al. show that data on the characteristics of the loan can be used to merge homes sales with HMDA data on loans, which provides a measure of household income.[5] The merge data allows us to compare taxes to income for a large number of households in several large urban counties.

We have conducted this set of analyses for our sample of four large central city counties. Again, we base our measures of taxes on actual values, estimates obtained by applying the statutory code to actual assessments, and estimates using sales prices in place of assessments. Figure 5

[5] We are grateful to Alvin Murphy for generously providing the code to merge the two data sets.

illustrates the results for Baltimore.[6] The first panel of Figure 5 presents the actual figure for ln(Tax/Income) against ln(Income). The implied average tax rate clearly declines with income. The lower left panel shows the results when the estimate of taxes is based on assessments. The main difference between these two sets of results is the availability of other exemptions beyond the basic homestead exemption for actual taxes. Overall, the results look similar for actual average tax rates and the rates calculated using assessed values. The results look somewhat different when average tax rate are calculated using the statutory schedule and actual sales prices. These results, which are shown in the upper right panel of Figure 5, imply a broad region of in the middle of the income distribution where average tax rates are increasing modestly with income. This upper-sloping region is one where the effect of the exemption is tapering off faster than the rate of decline of P/I with income. The last panel of Figure 5 directly compares the other three panels using the predictions from locally weighted regressions of $\ln(T/I)$ on $\ln(I)$. The results suggest that the average tax burden would be lower for low-income households if homes were assessed at actual sales prices in Baltimore.

Table 4 presents the average tax rates for the set of four counties. We calculate T/I using actual taxes and our two estimates of taxes, and compare the results across percentiles of the local income distribution. The lowest-income homeowners – those in the lowest 10% percentile of the local distribution – always face a higher average tax burden than those with higher income. In every case, there is a monotonic decline in the average tax rate with income, including those cities with large exemptions (need to provide the data on exemptions in the table). On the one hand, Table 4 can be taken as confirming evidence of Albouy, Erlich, and Liu's (2016) conclusion that

[6] We have trimmed the data to remove observations for which tax (or estimated tax) as a fraction of income is less than 1%.

the income elasticity of demand is under one, and by enough to offset the homestead exemption. The results are also evidence that the common view that the property tax is regressive is correct, at least when income is measure using current values rather than a measure of permanent income.

7. Conclusion

The common view that the property tax is regressive is not a necessary implication of the tax code. Since many jurisdictions have substantial homestead exemptions, the statutory incidence of the tax is progressive when progressivity is measured as an increase in the implied tax payment per dollar of property value. However, the income elasticity of demand for housing is generally accepted to be under one, which implies that a moderately progressive tax structure can still produce a regressive tax when regressivity is measured using income in the denominator rather than sale price.

The lack of data sets combining sales prices, assessments, and household income has resulted in a distinct lack of empirical analysis of the relationship between property tax payments and household income. In this study, we have combined data on property sales with HMDA data on loans to calculate average tax payments for recent transactions of homes finance using mortgages. We find that the common view that the property tax is regressive is correct: for each of the four large central city counties, taxes per dollar of household income decline with income in every case. The average tax for households in the lowest 10th percentile of the local income distribution is nearly double the average tax for households in the highest 10th percentile.

Assessment regressivity has the potential to accentuate the degree of property tax regressivity. A stylized fact from the assessment literature is that low-priced properties tend to be assessed at higher rates than low-priced properties. We find evidence of regressive assessment practices in Baltimore, Cleveland, and Philadelphia when we measure regressivity using either the traditional PRD or using a measure proposed here, the Gini coefficient. Even in Denver, a county with relatively accurate assessment practices (although at lower than the statutory rate), the results imply a pattern of regressivity in a region of very low sales prices. These findings suggest that assessment practices tend to increase the degree of regressivity of the property tax system, and in jurisdictions with homestead exemptions the degree of assessment regressivity may be sufficient to reverse what otherwise could be a progressive property tax schedule.

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Table 1: Assessment Statistics

City	Statute	Exemption	Mean	Median	Wgt. Mean	COD	Wgt. COD	PRD	N
Baltimore, MD (Baltimore County)	1	0	1.106	0.888	0.841	47.803	27.715	1.316	11,984
			(0.006)	(0.003)	(0.003)	(0.465)	(0.245)	(0.005)	
Cleveland, OH (Cuyahoga County)	0.35	0	0.266	0.236	0.230	38.532	31.648	1.160	22,921
			(0.001)	(0.001)	(0.001)	(0.224)	(0.180)	(0.003)	
Denver, CO (Denver County)	0.0796	0	0.060	0.060	0.059	22.480	22.604	1.015	23,497
			(0.000)	(0.000)	(0.000)	(0.140)	(0.166)	(0.001)	
Philadelphia, PA (Philadelphia County)	1	40,000	0.953	0.905	0.824	30.443	26.447	1.158	21,904
			(0.003)	(0.002)	(0.003)	(0.199)	(0.196)	(0.003)	

Note. Standard errors are in parentheses.

Table 2: Gini Coefficients for Sales Prices and Assessments

City	Real Sale Price (P)	Assessed Value (A)	(A-P)
Baltimore, MD	0.423	0.302	-0.121
	(0.002)	(0.003)	(0.002)
Cleveland, OH	0.390	0.298	-0.092
	(0.002)	(0.003)	(0.002)
Denver, CO	0.299	0.289	-0.010
	(0.002)	(0.002)	(0.002)
Philadelphia, PA	0.386	0.287	-0.099
	(0.002)	(0.003)	(0.002)

Note. Standard errors are in parentheses.

Table 3: Gini Coefficients for Taxes

City	Actual Tax	Estimated Tax on Assessed Values (T1)	Estimated Tax on Real Sale Price (T2)	(T2 - T1)/T1
Baltimore, MD	0.333	0.338	0.422	0.084
	(0.003)	(0.002)	(0.003)	(0.002)
Cleveland, OH	0.330	0.354	0.387	0.033
	(0.002)	(0.002)	(0.002)	(0.002)
Denver, CO	0.352	0.336	0.299	-0.037
	(0.002)	(0.002)	(0.002)	(0.001)
Philadelphia, PA	0.314	0.428	0.473	0.045
	(0.002)	(0.002)	(0.003)	(0.002)

Note. Standard errors are in parentheses.

Table 4: Tax Divided by Income

City	Tax Calculation	0 - 10%	10% - 25%	25% - 50%	50% - 75%	75% - 90%	90% - 100%
Baltimore, MD	Actual Tax	8.273	6.703	6.080	4.881	3.895	3.218
	Estimated Tax	7.937	6.441	5.970	4.873	4.021	3.271
	Tax Based on Sale Price	6.901	6.449	6.161	5.220	4.324	3.498
Cleveland, OH	Actual Tax	9.323	7.595	6.758	5.753	4.886	4.209
	Estimated Tax	8.680	7.159	6.599	5.862	5.161	4.421
	Tax Based on Sale Price	7.318	6.264	5.844	5.250	4.681	3.946
Denver, CO	Actual Tax	3.432	2.838	2.573	2.298	2.123	1.915
	Estimated Tax	3.424	2.841	2.576	2.340	2.135	1.973
	Tax Based on Sale Price	3.319	2.773	2.469	2.110	1.865	1.698
Philadelphia, PA	Actual Tax	7.471	5.180	4.295	3.485	2.871	2.481
	Estimated Tax	6.064	4.420	4.023	3.527	3.206	2.928
	Tax Based on Sale Price	4.829	3.729	3.588	3.287	3.044	2.936

Figure 1: Assessment Ratios and Log Sale Price

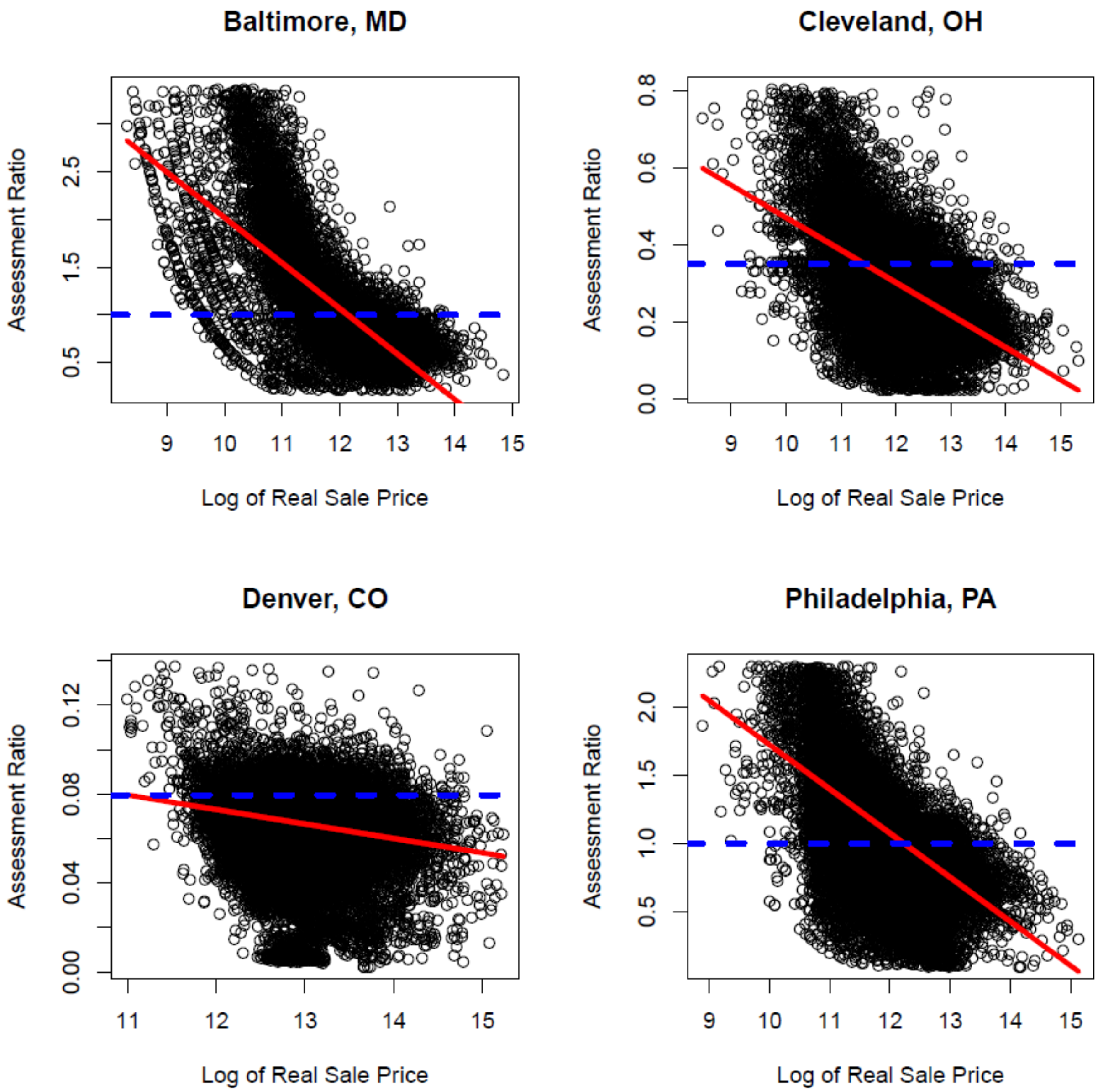

Figure 2: Conditional Density Functions for Assessment Ratios

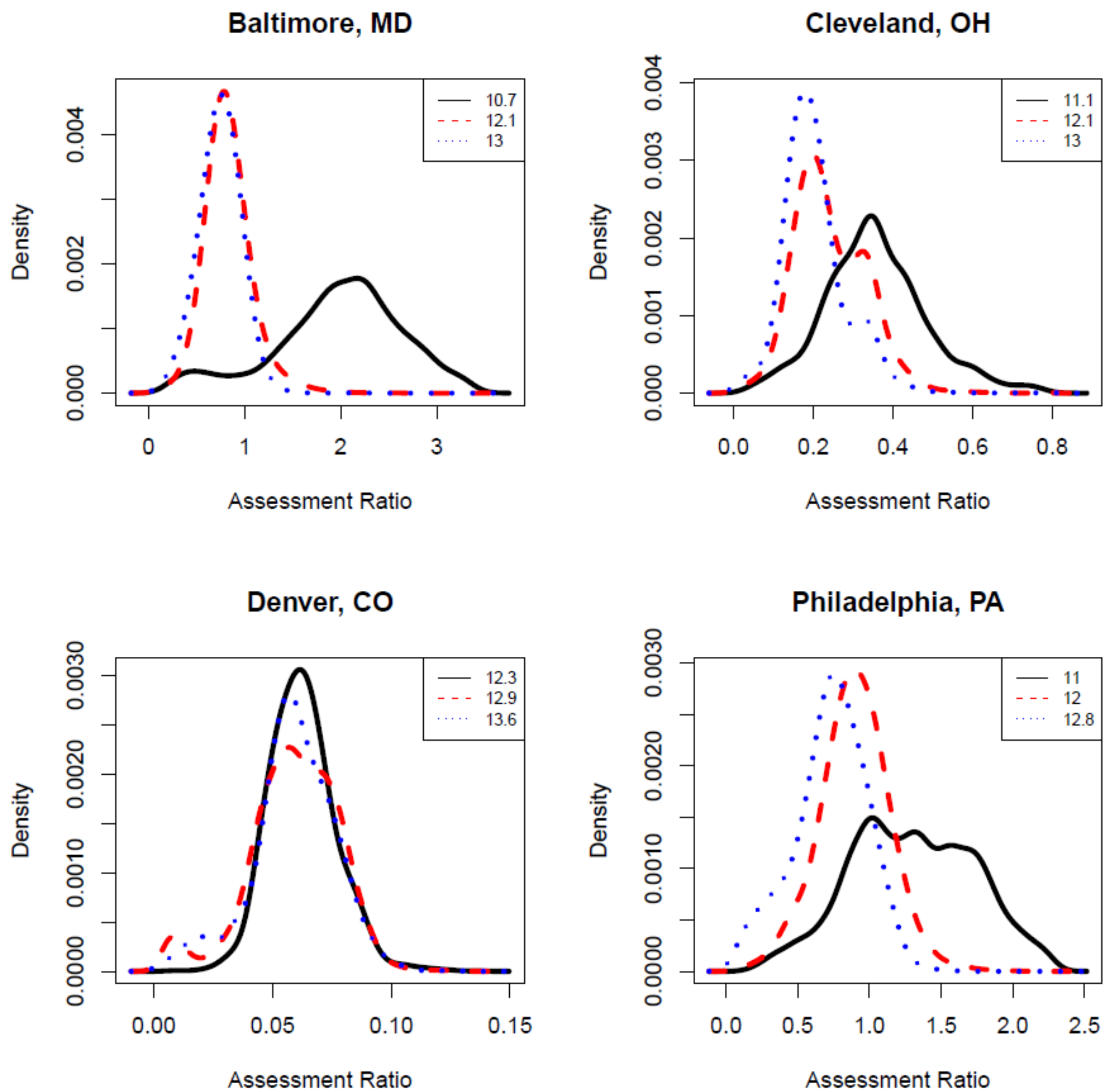

Figure 3: Lorenz Curves for Sales Prices and Assessments

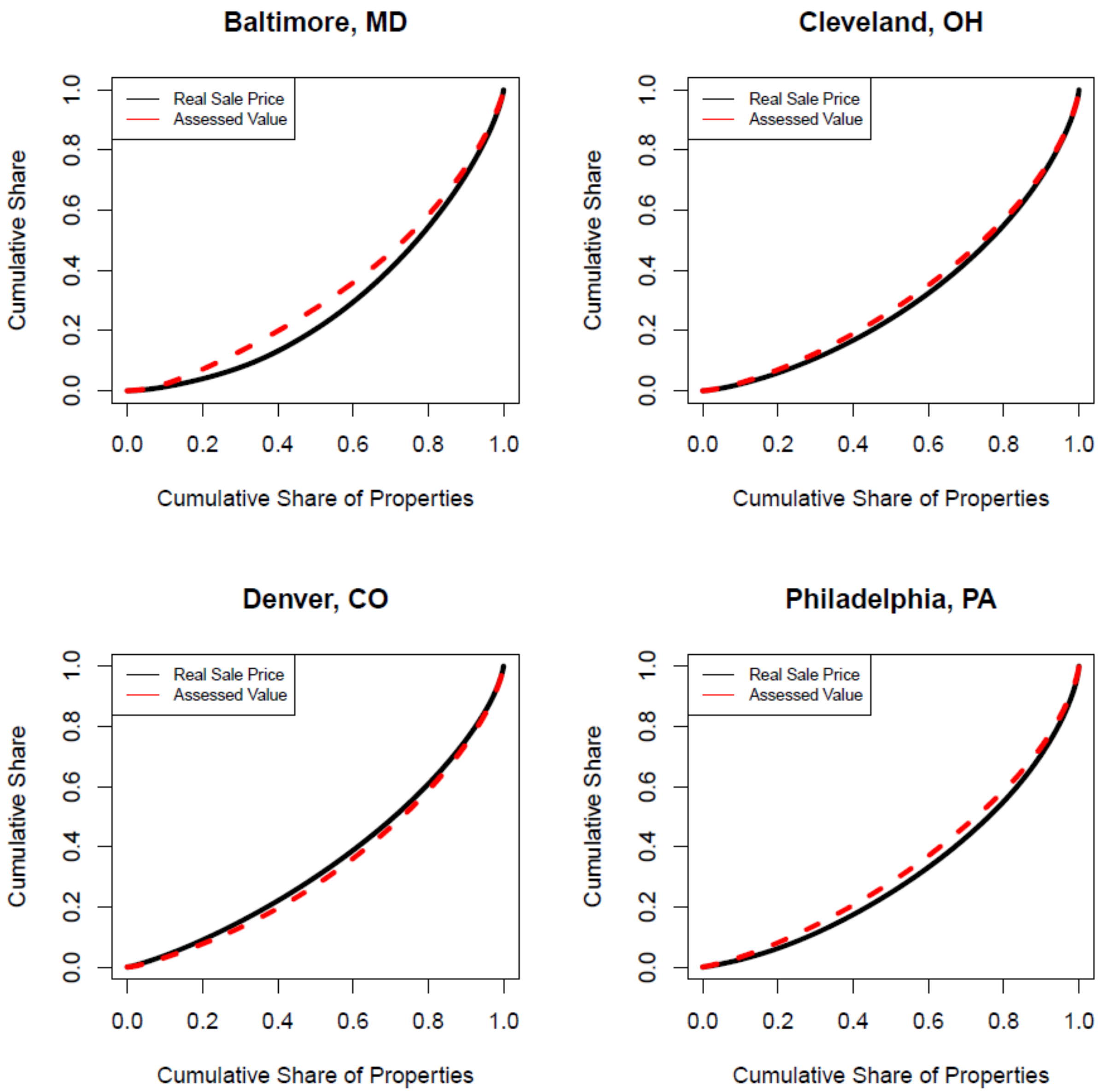

Figure 4: Effective Tax Rates

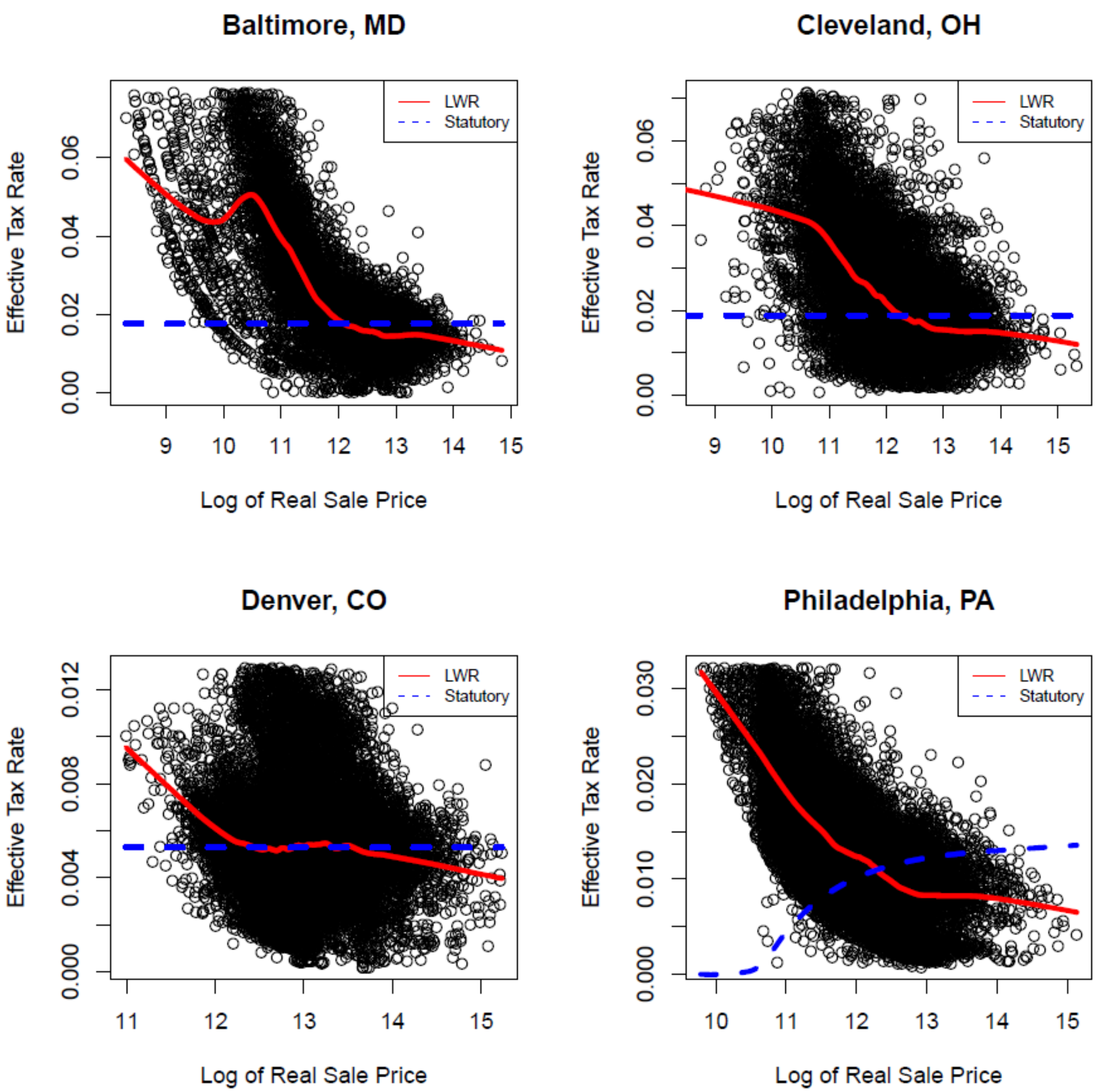

Figure 5: Tax/Income and Log of Income, Baltimore